Methylene Blue Dye Adsorption Study Using Silk Polymorphs

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IN

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BY

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SYNOPSIS

The silk produced by *Bombyx mori* is a semi-crystalline natural biopolymer having a very long history in the textile industry as well as in the biomedical field. In the last few decades, this silk has found uses well beyond routine textile and medical suture. The protein polymer is explored as a technological material and finds unique new applications in unexpected places. Silk normally consists of two main proteins namely, fibroin, a core in the fibre, and sericin, a coating material. In the recent past, regenerated SF and sericin have been found to be a very valuable material and have been utilized in the fabrication of fibres, powder, microspheres, films, nanocomposites, and porous scaffolds for diverse applications.

In recent years, the fabrication of microspheres in general and porous microspheres in particular, has gained greater importance due to their large surface area and high volume content. The microspheres have many potential applications in different areas such as delivery agents for drugs, cell culture substrates, cosmetics, and inks and dyes. For instance, SF microparticles are prepared and used as sustained drug release vehicles for intra-articular delivery. The ultrafine SF powder is produced and studied for its dye removal ability. Microspheres or microparticles are generally a class of particulates that have diameters from high nanometer (1–1000 nm) to micron range (1–1000 mm) and assume a spherical shape. The particulates are fabricated using ceramics, polymers, and their composites via several techniques/procedures. SF microspheres can also be produced by blending SF with low-molecular weight HPMC polymer.

Also, it is well-known that the free standing SF and nanocomposite films were prepared and studied for their suitability in a range of applications. SF and nanocomposite films have remarkable mechanical properties, low surface roughness, high refractive index, and are transparent in the visible region. The outstanding properties make it an appropriate candidate for a wide scope of optical devices, luminescent solar concentrator, and in many other areas. Normally, a nanocomposite is a system that consists of two or more different materials among which one of the components has dimension less than 100 nm. Generally, polymeric is a simple strategy for combining different materials in order to better the deficient properties of a particular material. The two important methods which are used for the development of polymer nanocomposites are *ex-situ* and *in-situ*. These methods are primarily liquid-based and the end product is solid and obtained either by co-precipitation or by simple-solvent evaporation. The *in-situ* formation of nanoparticles in a polymer matrix is the simplest and effective approach to fabricate nanocomposites. This route permits the one-step preparations of nanocomposites in which *in-situ* generate nanoparticles from their precursors. In this process, the nanoparticles are generated inside the polymer matrix. The advantage of this route is that it prevents particle agglomeration and maintains good spatial distribution in the polymer matrix. The fabricated nanocomposite consists of an organic silk biopolymer matrix and gold inorganic components. Gold nanoparticles have unique electronic, thermal, optical, and chemical properties. Also, SF films are prepared and investigated for its azo dye adsorption capacity.

The properties of the AuNPs, SF, SF-AuNPs nanocomposites, SF microparticles, and SF-rGO BNCs including optical properties, functional groups, crystallite size, surface morphology, nanoparticles shape, size, and hydrodynamic size of the particles were studied. For this UV-Visible spectroscopy (UV-Vis), Fourier transform infra-red spectroscopy (FT-IR), Fluorescence spectroscopy, X-ray diffraction (XRD) study, Scanning electron microscope (SEM), Transmission electron microscope (TEM), X-ray photoelectron spectroscopy (XPS), Dynamic light scattering (DLS), Differential scanning calorimetry (DSC), Thermogravimetric analysis (TGA), Universal testing machine (UTM), and Raman spectroscopy (RS) experiments have been employed. Further, the adsorption studies of the samples were carried out. The work carried out was documented in this thesis and is divided into seven chapters. The details of each chapter are given below.

Chapter 1

The first chapter describes a general introduction of the nanoparticles, microparticles, SF and SF-AuNPs nanocomposites using green or bio-based procedures. The history and development of eco-friendly approaches for the preparation of microparticles, SF, and SF-AuNPs nanocomposites are focused in this chapter. A review of literature is included covering various methods used for the microparticles, SF, SF-AuNPs nanocomposites, and SF-rGO BNCs along with properties such as structural, optical, size distribution, particles morphology, and potential applications. The importance and objectives of the present research work are also given in this chapter.

Chapter 2

The second chapter deals with the details of the experimental methods and analytical techniques used in the present work. It describes the preparation of the SF solution, SF-AuNPs colloidal solution, and preparation of microparticles, SF, SF-AuNPs nanocomposites, and the experimental facilities used for the study. A brief theory/experimental details of the UV-Vis, FT-IR, XRD, SEM, TEM, XPS, Fluorescence, DLS, DSC, TGA/DTG, UTM, Raman spectroscopy, and light sources are presented. Detailed procedures for the assessment of the MB dye adsorption study and properties are also discussed in this chapter.

Chapter 3

Chapter three describes the facile fabrication of silk fibroin microparticles: their characterization and potential adsorption study. In this work, SF microparticles were fabricated by blending of SF solution with HPMC and the SF/HPMC blend films were prepared using a simple-solvent evaporation technique. The SF/HPMC blends were dissolved in ultrapure water and SF microparticles were generated with and without sonication. Different analytical techniques like FT-IR, SEM, EDS, DLS, DSC, and TGA/DTG measurements were used for the characterization of blend films and microparticles. The microparticles obtained with sonicated consists of nano sized pores on the surface. The size of the pores was nano but the diameter of particles was around 10 μm. Further, SF microparticles evaluated as a novel biosorbent for the methylene blue (MB) a cationic dye. The influential factors (pH, contact time) to the adsorption of the dye by the microparticles were investigated. The SF microparticles showed a very

good adsorption capacity of about 490 (non-sonicated) and of about 512 (sonicated) mg g^{-1} of the dye without any surfactants. The adsorption kinetics validates the practicality of using the pseudo-second-order kinetics. Langmuir and Freundlich isothermal models were used and the results showed that the adsorption behaviour of the samples best fits (R^2=0.998) the Langmuir model. A detail of the work was discussed in the thesis.

Chapter 4

Chapter 4 describes the synthesis of gold nano-colloids using *Bombyx mori* silk sericin and characterization. In this work, spherical gold nanoparticles were synthesized by the reduction of $HAuCl_4.H_2O$ using silk sericin (SS) under UV-radiation environment. The UV-Vis absorption spectra showed a localized surface plasmon resonance (LSPR) band in the wavelength range of 519-532 nm, which established the formation of the AuNPs. The fluorescence study revealed phenolic groups in the tyrosine residue as the most active functional group for the conversion of Au ions to Au neutral atoms. The TEM images showed spherical shaped AuNPs. Further, the nanocrystalline phase of gold with cubic crystal structure was recognized using the XRD measurements. Furthermore, the average hydrodynamic size distribution of gold nanoparticles was determined using the DLS experiment. The details of the work are discussed in detail in the chapter.

Chapter 5

Chapter five describes the silk fibroin and silk fibroin-gold nanoparticles nanocomposite films: sustainable adsorbents for methylene blue dye. In this chapter,

the preparation of SF and silk fibroin-gold nanoparticles nanocomposites (NC) and their adsorbability of MB dye are reported. SF is used in this work as a template to reduce gold salt ($HAuCl_4.H_2O$) into AuNPs. The optical absorption displays the AuNPs in SF by showing a band at λ = 540 nm. The XRD and the TEM study reveal the crystalline nature of the AuNPs. The TEM image indicates that the AuNPs are mostly spherical in shape with an average diameter of around 6.22 ± 1.28 nm. The SEM micrograph shows the AuNPs as uniformly dispersed in the SF. The samples are evaluated as novel adsorbents, and influencing factors like solution pH, contact time, and kinetic models are investigated. The adsorption kinetics validates the practicality of the pseudo-second-order kinetics by best linear fit (R^2=0.987 for SF film) and (R^2=0.989 for SF-AuNPs NC film). The Langmuir and Freundlich isothermal models used in the study, maximum adsorption capacity for the dye are estimated to be 263.15 mg g^{-1} (SF) and 313.47 mg g^{-1} (SF-AuNPs). The decolourization percentage is about 95.62% (SF) and 98.66% (SF-AuNPs). The recycle tests demonstrate that the samples can be reused 4 times with removal efficiency of more than 80%. The results suggest that the SF and SF-AuNPs films can be used as an efficient sorbents for MB dye removal from a solution.

Chapter 6

Chapter six describes the novel conductive silk fibroin *in-situ* reduced graphene oxide bionanocomposites. This research describes the fabrication of bionanocomposites (BNCs) based on SF and reduced graphene oxide (rGO). The UV-Vis spectra of the sample confirms the reduction of GO to rGO in SF by showing

plasmon resonance band within the wavelength range of 261 - 268 nm. The XRD peak at 11.6° corresponding to GO intensity decreases with increasing reaction time resulting in rGO in the SF. The morphological behaviour of the SF-rGO BNCs is scrutinized using the SEM, and the images indicate the existence of rGO within the matrix. The increasing amount of GO in the SF shows broken graphene sheets, which can increase surface roughness and establish a strong physical contact between the SF and rGO nanosheets. The rGO effect on electrical conductivity is measured, and the results show that DC conductivity increases from 1.28×10^{-9} to 82.4×10^{-9} S cm^{-1} with an increase in the GO content in the SF. The investigations demonstrate the loss of the insulation property and improved conducting behaviour of the SF. The detailed investigations on the properties and electrical property of pure SF and SF-rGO have been presented in the thesis.

Chapter 7

The overall summary of the results from the studies carried out and suggestions for future work are given in chapter seven. Most of these results and discussions have been published/communicated in peer reviewed international journals.

Publications of the Author

A. Research Papers Published in National/International Journals

[1] Synthesis of Anisotropic Silver Nanoparticles using Silk Fibroin: Characterization and Antimicrobial Properties, Y. Sangappa, S. Latha, S. Asha, P. Sindhu, **N. Parushuram**, M. Shilpa, K. Byrappa, and B. Narayana, ***Materials Research Innovations*** (Taylor and Francis), 2019, *23,* 79-85. DOI: 10.1080/ 14328917.2017.1383680

[2] Eco-synthesis of Gold Nanoparticles by Sericin Derived from *Bombyx mori* Silk and Catalytic Study on Degradation of Methylene Blue, K. S. Harisha, **N. Parushuram**, S. Asha, S. B. Suma, B. Narayana, and Y. Sangappa, ***Journal of Particulate Science and Technology*** (Taylor and Francis), 2019. DOI: 10.1080/02726351.2019.1666951

[3] Facile Fabrication of Silk Fibroin Microparticles: Their Characterization and Potential Adsorption Study, **N. Parushuram**, R. Ranjana, B. Narayana, M. Mahendra, and Y. Sangappa, ***Journal of Dispersion Science and Technology*** (Taylor and Francis), 2020, DOI: 10.1080/01932691. 2020.1774383

[4] Fabrication and Characterization of Conductive Silk Fibroin - Gold Nanocomposite Films, R. Ranjana, **N. Parushuram**, K. S. Harisha, S. Asha, B. Narayana, M. Mahendra, and Y. Sangappa, ***Journal of Materials Science: Materials in Electronics*** (Springer), 2020, *31,* 249–264. DOI:10.1007/s10854-019-02485-5

[5] Photo-driven Synthesis of Anisotropic Gold Nanoparticles Using Silk Fibroin – Cell Viability Activities in Lymphocyte and Jurkat Cancer Cells, R. Ranjana, **N. Parushuram**, K. S. Harisha, B. Narayana, and Y. Sangappa, ***BioNanoScience*** (Springer), 2020, *10,* 864-875. DOI: 10.1007/s12668-020-00772-8

[6] Fabrication of SF and SF-AuNPs Nanocomposite Films: Characterization and Adsorbability Study on Methylene Blue Dye, **N. Parushuram**, R. Ranjana, K. S. Harisha, M. Shilpa, B. Narayana, R. Neelakandan, and Y. Sangappa, ***Journal of Dispersion Science and Technology***, (Taylor and Francis), 2020, DOI: 10.1080/01932691.2020.1848578

[7] Green Synthesis of Spherical Gold Nanoparticles Using *Bombyx mori* Silk Sericin: Characterization and its Activity in MOLT-4 Cancer Cell Line, **N. Parushuram**, R. Ranjana, S. Asha, K. S. Harisha, S. K. Ajay, B. Narayana, R. Somashekar, and Y. Sangappa, ***BioNanoScience*** 2021 (Springer), (Under review - EMID:b0e3904f3e21efd8)

[8] Novel Conductive *in-situ* Reduced Graphene Oxide - Silk Fibroin Bionanocomposites, **N. Parushuram**, B. U. Gauthama, R. Ranjana, K. S. Harisha, Lavita J. Martis, B. Narayana, and Y. Sangappa, ***ACS Omega*** 2021, DOI 10.1021/acsomega.1c00013

[9] Silk Fibroin a Bio-Template for Synthesis of Different Shaped Gold Nanoparticles: Characterization and Ammonia Detection Application, R. Ranjana, **N. Parushuram**, K. S. Harisha, S. Asha, and Y. Sangappa, ***Materials Today: Proceedings*** (Elsevier), 2020, *27,* 434-439. DOI: 10.1016/j.matpr.2019.11.259

[10] Synthesis and Characterization of Gold Nanoparticles, R. Ranjana, S. Asha, **N. Parushuram**, K. S. Harisha, B. Narayana, K. Byrappa and Y. Sangappa, ***American Institute of Physics, Conference Proceedings,*** 2018, *2009,* 020042-1-020042-4. DOI: 10.1063/1.5052111

[11] Synthesis of Silver Nanoparticles Using *Bombyx Mori* Silk Fibroin and Antibacterial Activity, K. S. Harisha, M. Shilpa, S. Asha, **N. Parushuram**, R. Ranjana, B. Narayana, and Y. Sangappa, ***Institute of Physics (IOP) Conference Proceedings Materials***

Science and Engineering, 2019, *577,* 012008. DOI: 10.1088/1757-899X/ 577/1/ 012008

[12] Biosynthesis of Spherical Gold Nanoparticles and Their Characterization, **N. Parushuram**, S. Asha, R. Ranjana, K. S. Harisha, M. Shilpa, B. Narayana, and Y. Sangappa, ***Institute of Physics (IOP) Conference Proceedings Materials Science and Engineering***, 2019, *577,* 012007. DOI: 10.1088/1757-899X/577/1/012007

[13] Green Synthesis of High Yield Mono-dispersed Gold Nanoparticles Using Silk-Sericin and Characterization, **N. Parushuram**, S. Asha, S. B. Suma, K. Krishna, R. Neelakandan, and Y. Sangappa, ***American Institute of Physics, Conference Proceedings,*** 2019, *2142,* 150016-1–150016-5. DOI: 10.1063/1.5122 565

[14] Silk Sericin a Bio-template for the Synthesis of Silver Nanoparticles and Characterization, M. Shilpa, K. S. Harisha, S. Asha, **N. Parushuram**, R. Ranjana, and Y. Sangappa, ***American Institute of Physics, Conference Proceedings,*** 2019, *2142,* 150024-1–150024-4. DOI: 10.1063/1.5122573

[15] Green Synthesis of Silver Nanoparticles Using Natural Biomaterial, K. S. Harisha, M. Shilpa, S. Asha, **N. Parushuram,** D. C. Harish kumar, B. Narayana, and Y. Sangappa, ***American Institute of Physics, Conference Proceedings,*** 2019, *2142,* 150012-1–150012-5. DOI: 10.1063/1.5122561

[16] Radiation Induced Effects on Silk Fibroin Films, S. Asha, **N. Parushuram**, K. S. Harish, S. Ganesh, and Y. Sangappa, ***American Institute of Physics, Conference Proceedings,*** 2019, *2142,* 150027-1–150027-4. DOI: 10.1063/1.5122576

[17] Green Synthesis of Silver Nanoparticles and Their Characterization, S. Latha, M. Shilpa, **N. Parushuram**, and Y. Sangappa, ***American Institute of Physics, Conference Proceedings,*** 2020, *2220,* 020192. DOI: 10.1063 /5.0001143

[18] Characterization and Antibacterial Properties of Biogenic Spherical Silver Nanoparticles, K. S. Harisha, **N. Parushuram**, R. Ranjana, J. Lavita Martis, B. Narayana, and Y. Sangappa, ***Materials Today: Proceedings*** (Elsevier), 2020. DOI: 10.1016/j.matpr.2020.09.654

[19] High Stable Colloidal Gold Nanoparticles using Biopolymer Silk Sericin: Characterization and Antibacterial Activity, **N. Parushuram**, R. Ranjana, K. S. Harisha, J. Lavita Martis, and Y. Sangappa, ***Materials Today: Proceedings*** (Elsevier), 2020. DOI: 10.1016/j.matpr.2020.11.854

[20] Structural, Morphological and Electrical Properties of PVA/Au Nanocomposite Films, J. Lavita Martis, **N. Parushuram**, and Y. Sangappa, ***Institute of Physics, Conference Proceedings Materials Science and Engineering,*** **Accepted.**

B. Papers presented in National and International Conferences /Symposia etc.

[1] **N. Parushuram,** R. Ranjana, S. Asha, R. Madhukumar, K. Byrappa, B. Narayana, and Y. Sangappa, Radiation-Assisted Synthesis and Characterization of Silver Nanoparticles, National Conference on PAIR-2017, April 11-13, 2017, Mangalore University, Karnataka.

[2] K. S. Harisha, **N. Parushuram,** B. Narayana, K. Byrappa, and Y. Sangappa, Effect of UV-irradiation on Structural, Chemical and Thermal Properties of Pullulan films, National Conference on PAIR-2017, April 11-13, 2017, Mangalore University, Karnataka.

[3] M. Shilpa, **N. Parushuram,** B. Lakshmeesha Rao, S. Asha , B. Narayana, K. Byrappa, and Y. Sangappa, Colloidal Silver Nanoparticles: Synthesis and Characterization, National Conference on PAIR-2017, April 11-13, 2017, Mangalore University, Karnataka.

[4] B. Lakshmeesha Rao, **N. Parushuram,** K, Sharat Chandra, R. Somashekar, K. Byrappa, and Y. Sangappa, Structural Mechanical and Antibacterial Properties of Gamma irradiated HPMC-ZnO Films, National conference on POLYCON-2017, September 15-16, 2017, JSS Engineering College, Mysore, Karnataka.

[5] **N. Parushuram,** R. Ranjana, K. S. Harisha, S. Asha, B. Narayana, K. Byrappa, and Y. Sangappa, Rapid Synthesis of Gold Nanoparticles Using Silk Fibroin: Characterization and Antibacterial Activity, International conference AFMEEB-2017, December 11-12, 2017, Madurai Kamaraja University, Madurai-TN.

[6] K. S. Harisha, M. Shilpa, **N. Parushuram,** R. Ranjana, G. Rajesh Shetty, S. Asha, B. Narayana, K. Byrappa, and Y. Sangappa, Silk Fibroin/Hydroxypropyl Methyl Cellulose (HPMC) Blend Films: Preparation and Characterization, International Conference - AFMEEB-2017, December 11-12, 2017, Madurai Kamaraja University, Madurai-Tamil Nadu.

[7] R. Ranjana **N. Parushuram,** K. S. Harisha, B. Narayana, K. Byrappa, and Y. Sangappa, Gold Nanoparticles Synthesis and Characterization, International Conference on AFMEEB-2017, December 11-12, 2017, Madurai Kamaraja University, Madurai-TN.

[8] **N. Paruishuram,** R. Ranjana, K. S. Harisha, S. Asha, K. Byrappa, B. Narayana, L. N. Madhu, and Y. Sangappa, Rapid Synthesis of Gold Nanoparticles Using Silk

Fibroin: Characterization and Anticancer Properties, International Conference on RAMSB-2018, January 23-25, 2018, Mangalore University, Karnataka.

[9] K. S. Harisha, M. Shilpa, S. Asha, **N. Parushhuram,** R. Ranjana, K. Byrappa, B. Narayana, and Y. Sangappa, Biogenic Synthesis of Silver Nanoparticles and Their Characterization, International Conference on RAMSB-2018, January 23-25, 2018, Mangalore University, Karnataka.

[10] R. Ranjana, S. Asha, **N. Parushuram,** K. S. Harisha, M. Shilpa, B. Narayana, K. Byrappa, and Y. Sangappa, Photo-Driven Synthesis and Characterization of Gold Nanoparticles, International Conference on RAMSB-2018, January 23-25, 2018, Mangalore University, Karnataka.

[11] M. Shilpa, K. S. Harisha, S. Asha, **N. Parushuram,** R. Ranjana, B. Narayana, K. Byrappa, and Y. Sangappa, Silver Nanoparticles Using *Bombyx mori* Silk Sericin and Their Characterization, International Conference on RAMSB-2018, January 23-25, 2018, Mangalore University, Karnataka.

[12] **N. Parushuram,** S. Asha, R. Ranjana, K. S. Harisha, M. Shilpa, B. Narayana, K. Byrappa, and Y. Sangappa, Bio-Synthesis of Gold Nanoparticles and Their Characterization, National Conference on Advanced Materials and Nanotechnology (AMN-2018), March 15-17, 2018, JIIT, Noida, U.P.

[13] K. S. Harisha, M. Shilpa, S. Asha, **N. Parushuram,** R. Ranjana, B. Narayana, K. Byrappa, and Y. Sangappa, Synthesis of Silver Nanoparticles Using *Bombox mori* Silk Fibroin and Antibacterial Activity, National Conference on AMN-2018, March 15-17, 2018, JIIT, Noida, U.P.

[14] M. Shilpa, K. S. Harisha**,** S. Asha, **N. Parushuram,** R. Ranjana, B. Narayana, K.

Byrappa, and Y. Sangappa, Synthesis of Silver Nanoparticles Using Silk Sericin and Their Characterization, National Conference on AMN-2018, March 15-17, 2018, JIIT, Noida, U.P.

[15] R. Ranjana, S. Asha, **N. Parushuram,** K. S. Harisha, M. Shilpa, B. Narayana, K. Byrappa, and Y. Sangappa, Synthesis of Anisotropic Gold Nanoparticles using Silk Fibroin, National Conference on AMN-2018, March 15-17, 2018, JIIT, Noida, U.P.

[16] **N. Parushuram,** S. Asha, R. Ranjana, K. S. Harisha, M. Shilpa, B. Narayana, and Y. Sangappa, Biosynthesis of Spherical Gold Nanoparticles and Their Characterization, 3rd International Conference on Advances in Materials and Manufacturing Applications, (IconAMMA-2018), August 16-18, 2018, Bangalore, Karnataka.

[17] K. S. Harisha, M. Shilpa, S. Asha, **N. Parushuram,** R. Ranjana, B. Narayana, and Y. Sangappa, Synthesis of Silver Nanoparticles Using *Bombyx Mori* Silk Fibroin and Antibacterial Activity, 3rd International Conference on Advances in Materials and Manufacturing Applications, (IconAMMA-2018), August 16-18, 2018, Bangalore, Karnataka.

[18] **N. Parushuram,** R. Ranajna, S. Asha, K. S. Harisha, B. Narayana, and Y. Sangappa, Biogenic Synthesise of Colloidal Gold Nanoparticles and Anticancer Activity, 10th Bengaluru India Nano, International conference, December 05-07, 2018, Bangalore, Karnataka.

[19] **N. Parushuram,** S. Asha, S. B. Suma, K. Krishna, R. Neelakandan, and Y. Sangappa, Green Synthesis of High Yield Mono-Dispersed Gold Nanoparticles Using Silk-Sericin and Characterization, International Conference on advances in basic sciences (ICABS19), February 07-09, 2019, Haryana.

[20] S. Asha, **N. Parushuram,** K. S. Harish**,** S. Ganesh, and Y. Sangappa, Radiation Induced Effects on Silk Fibroin Films, International Conference on advances in basic sciences (ICABS19), February 07-09, 2019, Haryana.

[21] K. S. Harisha, M. Shilpa, S. Asha, **N. Parushuram,** D. C. Harish kumar, B. Narayana, and Y. Sangappa, Green Synthesis of Silver Nanoparticles Using Natural Biomaterial, International Conference on advances in basic sciences (ICABS19), February 07-09, 2019, Haryana.

[22] M. Shilpa, K. S. Harisha, S. Asha, **N. Parushuram,** D. C. Harish kumar, B. Narayana, and Y. Sangappa, Silk Sericin a Bio-Template for The Synthesis of Silver Nanoparticles and Characterization, International Conference on advances in basic sciences (ICABS19), February 7-9, 2019, Haryana.

[23] **N. Parushuram,** R. Ranjana, S. Asha, K. S. Harisha, K. Byrappa, B. Narayana, R. Somashekar, and Y. Sangappa, UV-assisted Synthesis of Gold Nanoparticles Using *Bombyx Mori* Silk Sericin: Characterization and Catalytic Reduction of Methylene Blue, International Conference on Materials for advanced Technologies ICMAT-2019, June 23-27, 2019, Marina Bay Sands, Singapore.

[24] K. S. Harisha, S. Asha, **N. Parushuram,** B. Narayana, K. Byrappa, R. Somashekar, and Y. Sangappa, Biosynthesis of Silver Nanoparticles Using Textile Waste-Silk Sericin and Antibacterial Properties, International Conference on Materials for advanced Technologies (ICMAT-2019) June 23-27, 2019, Marina Bay Sands, Singapore.

[25] R. Ranjana, **N. Parushuram,** K. S. Harisha, S. Asha, and Y. Sangappa, Silk Fibroin a Bio- Template for Synthesis of Different Shaped Gold Nanoparticles:

Characterization and Ammonia Detection Application, 1st International Conference on Recent Advances in Materials Manufacturing, ICRAMM-2019 September 12-14, 2019, Belagavi, Karnataka.

[26] **N. Parushuram,** R. Ranajna, K. S. Harisha, B. Narayana, and Y. Sangappa, Microwave Assisted Synthesis of Gold Nanocolloids Using Textile Waste Silk Sericin: Characterization and Dye Decomposition of Methyl Orange, International Conference on Advance in Chemical and Materials Science, ICCM-2019, October 17-19, 2019, Mangalore University, Karnataka.

[27] K. S. Harisha, **N. Parushuram,** R. Ranjana, B. Narayana, and Y. Sangappa, Bio-Based Spherical Silver Nanoparticles by Silk Sericin: Its Antibacterial Activity, International Conference on Advance in Chemical and Materials Science, ICCM-2019, October 17-19, 2019, Mangalore University, Karnataka.

[28] S. Latha, M. Shilpa, **N. Parushuram**, and Y. Sangappa, Green Synthesis of Silver Nanoparticles and Their Characterization, 3rd International Conference on Condensed Matter and Applied Physics ICC-2019, October 14-15, 2019, Bikaner, Rajasthan.

[29] K. S. Harisha, **N. Parushuram,** R. Ranjana, M. J. Lavita, B. Narayana, and Y. Sangappa, Characterization and Antibacterial Properties of Biogenic Spherical Silver Nanoparticles, 2nd International Conference on Recent Advances in Materials Manufacturing, (ICRAMM-2020) November 20-21, 2020, Erode, Tamil Nadu.

[30] **N. Parushuram,** R. Ranjana, K. S. Harisha, M. J. Lavita, B. Narayana, and Y. Sangappa, Highly Stable Colloidal Gold Nanoparticles Using Biopolymer Silk Sericin: Characterization and Antibacterial Activity, 2nd International Conference

on Recent Advances in Materials Manufacturing, (ICRAMM-2020) November 20-21, 2020, Erode, Tamil Nadu.

C. Best Poster Award

1. **N. Parushuram,** S. Asha, S. B. Suma, K. Krishna, R. Neelakandan, and Y. Sangappa, Green Synthesis of High Yield Mono-Dispersed Gold Nanoparticles Using Silk-Sericin and Characterization, **International Conference on Advances in Basic Sciences** (ICABS19), February 07-09, 2019, **Haryana.**

D. Foreign Visit – to Attend and Present Research Paper

1. **N. Parushuram,** R. Ranjana, S. Asha, K. S. Harisha, K. Byrappa, B. Narayana, R. Somashekar, and Y. Sangappa, UV-assisted Synthesis of Gold Nanoparticles Using *Bombyx Mori* Silk Sericin: Characterization and Catalytic Reduction of Methylene Blue, **International Conference on Materials for Advanced Technologies** ICMAT-2019, June 23-27, 2019, Marina Bay Sands, **Singapore**.

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Parushuram
Research Scholar
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